Soc Psychol Educ (2009) 12:529–560
DOI 10.1007/s11218-009-9097-z

Personal epistemology across cultures: exploring Norwegian and Spanish university students' epistemic beliefs about climate change

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Received: 30 June 2008 / Accepted: 2 June 2009 / Published online: 26 June 2009

Abstract The primary aim was to explore and compare the dimensionality of personal epistemology with respect to climate change across the contexts of Norwegian and Spanish students. A second aim was to examine relationships between topic-specific epistemic beliefs and the variables of gender, topic knowledge, and topic interest in the two contexts. Participants were 225 Norwegian and 217 Spanish undergraduates enrolled in psychology or education courses, and the dimensionality of topic-specific personal epistemology was explored through factor analyses of the scores on a 49-item questionnaire. Hierarchical multiple regression analyses were used to predict scores on the epistemic belief dimensions emerging from the factor analyses with gender, topic knowledge, and topic interest, respectively. Even though considerable cross-cultural generalizability in dimensionality was demonstrated, this research also draws attention to the cultural embeddedness of topic-specific epistemic beliefs. Moreover, differences in the predictability of topic knowledge and topic interest in Norway and Spain, suggest that factors constraining or enhancing adaptive epistemic beliefs concerning particular topics may vary across cultures.

Keywords Personal epistemology · Topic-specific epistemic beliefs · Topic knowledge · Topic interest · Cross-cultural research

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1 Introduction

The main aim of this study was to explore and compare the dimensionality of personal epistemology with respect to a particular scientific topic across the educational and cultural contexts of Norwegian and Spanish university students. Additionally, we wanted to explore the extent to which relationships between topic-specific epistemic beliefs and other relevant variables, specifically gender, topic knowledge, and topic interest, were similar or different across the two contexts.

In the last decades, educational psychologists have become increasingly interested in the conceptions of knowledge and knowing that students hold, with the term personal epistemology coined to distinguish between the lay person's view about knowledge and knowledge from the trained philosopher's view (Hofer and Pintrich 2002). Thus, the term personal epistemology essentially refers to the beliefs or theories that students (and other individuals) hold about knowledge and the process of knowing (Hofer and Pintrich 1997, 2002), that is, epistemic beliefs (Kitchener 2002). Currently, there is abundant evidence demonstrating the important role played by personal epistemology in students' academic motivation, cognition, and performance (for a review, see Bråten in press).

While much important work on personal epistemology has continued, Perry's (1970) early effort to identify developmental stages or sequences in students' epistemic thinking, mostly by conducting in-depth interviews (e.g., Baxter Magolda 1992; King and Kitchener 1994; Kuhn 1991), Schommer (1990) departed from the developmental paradigmatic approach (cf., Hofer 2004a) and introduced quantitative assessment in the form of a 63-item domain-general questionnaire allowing for group administration and statistical analyses of student scores. Schommer (1990) theoretically assumed that personal epistemology consisted of more or less independent beliefs about the certainty, simplicity, and source of knowledge, as well as beliefs concerning the speed of learning and the fixity of ability. Consequentially, she created two or three subsets of items to assess each of the five proposed dimensions and used the resulting 12 subsets of the 63 items as variables in factor analyses to empirically explore the dimensionality of personal epistemology. Those factor analyses (e.g., Schommer 1990, 1993; Schommer et al. 1997, 1992) consistently yielded four factors, which, stated from a naïve perspective, were: *certain knowledge* (ranging from the belief that knowledge is absolute and unchanging to the belief that knowledge is tentative and evolving), *simple knowledge* (ranging from the belief that knowledge is best characterized as isolated bits and pieces to the belief that knowledge is best characterized as highly interrelated concepts), *quick learning* (ranging from the belief that learning takes place quickly or not at all to the belief that learning is gradual), and *fixed ability* (ranging from the belief that ability to learn is given at birth to the belief that ability to learn can be increased). Thus, source of knowledge, which Schommer (1990) suggested would range from the belief that knowledge is handed down by authority to the belief that knowledge is derived from reason, was the only hypothesized dimension that did not emerge as a factor from those analyses.

However, with the use of common factor-analytic methodology, that is, individually factoring items rather than *a priori* subsets, the Schommer Epistemological Questionnaire (SEQ) has sometimes resulted in another dimensionality of personal

epistemology than that reported by Schommer and associates. (In fact, this has also happened with factoring based on subsets of items; e.g., Kardash and Howell 2000.) For example, when Qian and Alvermann (1995) conducted an item-based factor analysis of SEQ-scores after eliminating items related to the hypothesized dimension concerning source of knowledge, which had not emerged as a factor in prior research, certainty and simplicity of knowledge merged to one factor, appearing together with quick learning and fixed ability. Somewhat later, Hofer (2000) reported that an item-based factor analysis of the 32 items of the SEQ that fell on Qian and Alvermann's three factors yielded a four-factor solution where no single factor replicated the factors reported by Schommer. Nor did Hofer (2000) find the certainty/simplicity factor identified by Qian and Alvermann. When Schraw et al. (2002) individually factored all 63 items of the SEQ, they obtained a five-factor solution including only 11 items, where two factors (certain knowledge 1 and fixed ability) corresponded to factors reported by Schommer, and three other factors (incremental learning, certain knowledge 2, and integrative thinking) differed from her results. Notably, Schraw et al. identified two certainty factors representing different constructs. Whereas certain knowledge 1 concerned the likelihood that scientists will ultimately discover universal truths and, thus, represented the construct of "accessibility to certain knowledge", certain knowledge 2 concerned the degree to which certain knowledge exists and, thus, represented the construct of "likelihood of certain knowledge" (Schraw et al. 2002, p. 266).

In addition to factor analyses of students' SEQ-scores, scores on other domain-general personal epistemology questionnaires have been factor analyzed. For example, Jehng et al. (1993) reported that factor analysis of scores from a 51-item domain-general questionnaire, with 29 of the items taken from the SEQ, yielded five factors representing certainty of knowledge, source of knowledge, orderly learning, quick learning, and fixed ability, respectively. When Wood and Kardash (2002) analyzed scores on 58 items from the SEQ together with the 22 items that were unique to Jehng et al.'s (1993) questionnaire, they identified factors similar to simple knowledge, quick learning, and fixed ability in Schommer's scheme, as well as a factor corresponding to certain knowledge 2 (i.e., likelihood of certain knowledge) as identified by Schraw et al. (2002). In addition, Wood and Kardash identified a factor that was labelled "knowledge construction and modification", with high scores on this factor representing the view that knowledge is constantly evolving, is actively and personally constructed, and should be subject to questioning, and low scores representing the view that knowledge is certain, passively received, and accepted at face value. This last-mentioned factor bears some resemblance to orderly learning as identified by Jehng et al. (1993), as well as to a combination of incremental learning and integrative thinking as identified by Schraw et al. (2002). Finally, it should be mentioned that Schraw et al. (2002) succeeded in identifying all the five dimensions in Schommer's (1990) original conceptualization (i.e., certain knowledge, simple knowledge, source of knowledge, quick learning, and fixed ability) by individually factoring 28 items from a domain-general questionnaire constructed to assess the same dimensions in a more unambiguous and efficient way. Taken together, however, research on the dimensionality of domain-general personal epistemology has produced somewhat inconsistent findings (see also, DeBacker et al. 2008). One reason may be that students who respond to items written to assess general beliefs (e.g., "The only thing that is certain

is uncertainty itself"), may keep quite different domains and topics in mind while responding, and this, in turn, may lead to differences not only in levels but also in dimensionality of scores. Given this possibility, we turn to a brief review of research on the dimensionality of domain-specific personal epistemology.

The issue of domain-generality versus domain-specificity has been much debated in recent years (for reviews, see Buehl and Alexander 2001; Muis et al. 2006). What researchers in personal epistemology mean by "domain" seems to vary somewhat (Hofer 2006; Limón 2006). However, most of them use it synonymously with discipline (Hofer 2006; Muis et al. 2006). In accordance with this, we equate the term domain as comparable to discipline or academic domain in this article. When Muis et al. (2006) thoroughly reviewed the generality—specificity personal epistemology research conducted so far, they concluded that this is not really an issue of either—or. Rather, students hold both domain-general and domain-specific epistemic beliefs. This conclusion was also supported by a recent empirical study by Buehl and Alexander (2005), using cluster analysis to compare the student profiles that emerged from different dimensions of personal epistemology across the domains of mathematics and history. While the distinct epistemic belief profiles that emerged differed across the two domains, there was also some consistency in students' profile membership in mathematics and history, with this finding also in accordance with a dual-level conception of personal epistemology.

In a first investigation of the dimensionality domain-specific personal epistemology, Hofer (2000) built on a theoretical framework for personal epistemology proposed by Hofer and Pintrich (1997). Hofer and Pintrich (1997) reviewed the existing literature on personal epistemology and argued convincingly that beliefs concerning learning (e.g., quick learning) and intelligence (e.g., fixed ability) should not reside within the boundaries of this construct. Instead, they proposed that personal epistemology exclusively consists of two dimensions concerning the nature of knowledge (what one believes knowledge is) and two dimensions concerning the nature or process of knowing (how one comes to know). Within the area of the nature of knowledge, the hypothesized dimensions *certainty of knowledge* and *simplicity of knowledge* correspond to certain knowledge and simple knowledge as described by Schommer (1990). Within the area of nature of knowing, the dimension *source of knowledge* was hypothesized to range from the conception that knowledge originates outside the self and resides in external authority, from which it may be transmitted, to the conception that knowledge is actively constructed by the person in interaction with others. At least in part, this dimension parallels the source dimension as described by Schommer (1990). The final dimension in the Hofer and Pintrich (1997) conceptualization, *justification for knowing*, also concerns the nature of knowing, with this dimension referring to how individuals justify and evaluate knowledge claims. This dimension, which seems to have no clear parallel within Schommer's (1990) belief system, was hypothesized to range from justification through observation and authority, or on the basis of what feels right, to the use of rules of inquiry and the evaluation and integration of multiple information sources.

Hofer (2000) devised a 27-item questionnaire to assess domain-specific epistemic beliefs, the Discipline-Focused Epistemological Beliefs Questionnaire (DFEBQ), and conducted exploratory factor analyses of item scores to empirically test the existence

and representation of the four dimensions proposed by Hofer and Pintrich (1997). On the DFEBQ, each item referred to a particular field or subject matter as a frame of reference (e.g., "In this field, knowledge is certain"), and the students were asked to keep either psychology or science in mind as they responded to the items. Hofer (2000) identified four factors underlying the DFEBQ-scores regardless of whether the domain was psychology or science. First, Hofer identified a certain/simple knowledge factor similar to the one reported by Qian and Alvermann (1995) with a domain-general questionnaire. Second, two factors representing source of knowledge and justification for knowing, respectively, emerged, even though those factors did not represent the full breadth of the hypothesized dimensions. Third, an unhypothesized factor labelled "attainability of truth" emerged, with this factor corresponding to "likelihood of certain knowledge" as identified by Schraw et al. (2002) and by Wood and Kardash (2002) with the use of domain-general measures.

Buehl et al. (2002) developed a questionnaire more specifically devised to assess domain-specific epistemic beliefs, the Domain-Specific Beliefs Questionnaire (DSBQ), with this instrument containing items focusing on either mathematics (e.g., "There are links between mathematics and other disciplines") or history ("There are links between history and other disciplines"). It should be noted that Buehl et al. (2002) originally wrote domain-specific items to capture the four dimensions identified by Schommer and associates with the SEQ (i.e., certain knowledge, simple knowledge, quick learning, and fixed ability) rather than the four dimensions included in the Hofer and Pintrich (1997) conceptualization. Using confirmatory factor analysis after first having explored the factor structure of a preliminary version of the DSBQ, and also after having eliminated items written to assess quick learning and fixed ability, respectively, Buehl et al. (2002) identified two corresponding epistemic belief dimensions in mathematics and history. Thus, in each domain a factor labelled "need for effort" was identified, with items included in this factor focusing on the extent to which students believed knowledge acquisition in mathematics and history, respectively, required time and effort. Additionally, a factor labelled "integration of information and problem solving" was identified in each domain, with items representing this factor focusing on the degree to which students believed knowledge in mathematics and history, respectively, to be integrated with knowledge in other areas in and out of school.

Some time later, Buehl and Alexander (2004) created a domain-specific personal epistemology measure by selecting items pertaining to beliefs about the certainty of knowledge and beliefs about authority as the source of knowledge from the DFEBQ (Hofer 2000) and items addressing beliefs about the isolation of knowledge from the DSBQ (Buehl et al. 2002). Each item specified that it concerned either history or mathematics (e.g., "Principles in history/mathematics are unchanging"). Buehl and Alexander (2004) reported that confirmatory factor analysis of the scores on the resulting measure yielded three corresponding factors in each domain, concerning beliefs about the certainty, simplicity, and source of knowledge, respectively (see also, Buehl and Alexander 2005).

At this point, it should be acknowledged that just as research on the dimensionality of domain-general personal epistemology has produced somewhat inconsistent findings, so has research on the dimensionality of domain-specific epistemic beliefs. One

likely reason for this is that investigations of domain-specific beliefs have also used different measures that, at least in part, are based on different conceptualizations of personal epistemology. Moreover, the fact that investigations of dimensionality in domain-general and domain-specific personal epistemology have used measures differing not only in terms of generality versus specificity but also in terms of theoretical framework, makes it difficult to judge how consistent corresponding factors appear across the two levels. Still, it should be noted that within each of the domain-specific investigations reviewed above, there was consistency in the dimensions that emerged across domains, with this suggesting that a set of more general epistemic beliefs might underlie beliefs specific to each domain (Buehl and Alexander 2004).

While most of the domain-general research on the dimensionality of personal epistemology was based on Schommer's (1990) conceptualization, current domain-specific research seems to be more inspired by Hofer and Pintrich's (1997) theoretical framework. However, being definitely the most influential framework for thinking about the dimensionality of personal epistemology in current educational psychology, the Hofer and Pintrich (1997) conceptualization could be said to suffer from an empirical deficit. At least, Hofer and Pintrich's (1997) conceptually derived dimensions have so far not been unequivocally empirically verified through factor analysis of questionnaire data (cf., Buehl 2008). Still, use of qualitative methodologies such as observations and interviews (Hofer 2004b) or think-aloud protocols (Hofer 2004c) suggests that all the four dimensions proposed by Hofer and Pintrich (1997) are represented in students' epistemic thinking. In the present study, however, we took a different tack and explored whether the dimensions proposed by Hofer and Pintrich could be identified at a topic-specific level of personal epistemology.

While the conclusion that personal epistemology includes levels of both domain generality and domain specificity has gained support in the literature (Buehl and Alexander 2001; Muis et al. 2006), a potentially useful distinction between domain-specific and topic-specific epistemic beliefs has received less attention. However, just as domain knowledge and topic knowledge may form subcategories of formally acquired or schooled knowledge, with domain knowledge referring to the breadth of one's knowledge about a domain (e.g., psychology or history), and topic knowledge representing the depth of one's knowledge about particular topics within a domain (e.g., motivation or World War II) (Alexander et al. 1991), beliefs about knowledge and knowing in a domain may be distinguished from epistemic beliefs about topics within domains (Bråten in press). It should be noted that while the term "topic" may, indeed, have several meanings, we use it in this article to refer to a more delimited subject area that can be subsumed under a discipline or academic domain. As an example of research on the topic-specific level of personal epistemology, Trautwein and Lüdtke (2007) recently used questionnaire items to examine students' epistemic beliefs about specific scientific theories, for example, about biological theories concerning natural selection and extinction of the dinosaurs, respectively. In that study, it was found that epistemic beliefs differed considerably across theories. Also, Stahl, Bromme, and their colleagues (Kienhues et al. 2008; Pieschl et al. 2008; Stahl and Bromme 2007) have started to focus on topic-specific personal epistemology. However, none of their efforts to examine the dimensionality in topic-specific personal epistemology through factor analysis, neither when using a semantic differential measure nor when using

a topic-specific version of Hofer's (2000) DFEBQ, have resulted in the four dimensions described by Hofer and Pintrich (1997). To further address this issue, we tried to construct a measure where each item fit into one of Hofer and Pintrich's (1997) four proposed dimensions, at the same time referring to beliefs concerning knowledge and knowing about a specific scientific topic—climate change. When responding to domain-specific items concerning knowledge and knowing, students may actually consider different topics within a domain. For example, while some students responding to items concerning the domain of history may reflect on World War II (1939–1945), others may reflect on the Persian wars (490 B.C. and 480–479 B.C.). Because students may hold different knowledge beliefs about the two topics (e.g., that knowledge about World War II is more certain than is knowledge about the Persian wars), a potential source of variance is eliminated when examining the dimensionality of topic-specific personal epistemology. Moreover, examining personal epistemology on a topic-specific level accords with a more general emphasis on contextual factors in research on academic learning and motivation (e.g., Bandura 1997; Bransford et al. 2000), and it involves a further contextualization in comparison with a focus on domain-specific beliefs. For example, by focusing on topic-specificity, research on personal epistemology is brought closer to the level of specificity focused in research on another set of powerful student beliefs, self-efficacy beliefs, which concern student beliefs about their capability to perform specific tasks (cf., Pajares 1996). Thus, there seem to be several reasons to extend research on the dimensionality of personal epistemology to include a topic-specific level.

In addition to addressing a topic-specific level of personal epistemology, we wanted to directly compare the dimensionality of epistemology across cultures in the present study. A decade ago, Hofer and Pintrich (1997) noted the paucity of cross-cultural research on epistemic beliefs, stating that "existing frameworks based on US samples are undoubtedly shaped by underlying cultural beliefs" (p. 130). In regard to the dimensionality issue, in particular, Schommer-Aikins (2002) emphasized the need to study the dimensionality of personal epistemology across cultures, suggesting that different factor structures might reflect cultural differences. In fact, several factor-analytic studies using Schommer's (1990) domain-general questionnaire or another domain-general instrument based on this, conducted in Asian (e.g., Chan and Elliot 2002; Youn et al. 2001) as well as in European (e.g., Bråten and Strømsø 2005; Clarebout and Elen 2001; Clarebout et al. 2001; Rozendaal et al. 2001) countries, have resulted in factor structures differing from that reported by Schommer and associates (for a review, see Buehl 2008). However, an issue with these studies is that they are limited to the use of domain-general measures, mostly based on the Schommer (1990) conceptualization (see, however, Karabenick and Moosa 2005). Moreover, only a couple of previous studies (Karabenick and Moosa 2005; Youn 2000) directly compared the dimensionality of personal epistemology across cultures. Given such limitations, the current research extended previous cross-cultural work on the dimensionality of personal epistemology in at least two ways. First, we based our topic-specific measure on the theoretical framework that Hofer and Pintrich (1997) developed after an extensive review of research conducted with US student samples. Second, we explored the cross-cultural generalizability of this influential framework by directly comparing the dimensionality of topic-specific personal epistemology across samples of Norwegian

and Spanish undergraduate university students. By measuring personal epistemology on a topic-specific level, we tried to ensure that participants in the two contexts did not have different domains or different topics within domains in mind while responding to questionnaire items.

Finally, we wanted to explore relations among topic-specific epistemic beliefs and gender, topic knowledge, and topic interest, respectively, in each cultural context. So far, findings regarding gender differences in personal epistemology have been inconsistent and, therefore, this issue merits further study. Whereas some studies (e.g., Enman and Lupart 2000; Hofer 2000; Schommer 1993; Schommer and Dunnell 1994; Wood and Kardash 2002) have found gender differences on only some dimensions, others (e.g., Buehl et al. 2002; Study III) have demonstrated a general lack of gender differences. According to Buehl et al. (2002), gender differences may be more pronounced when considered without regard to specific domains of knowledge, because when responding to items concerning knowledge and knowing in general, males and females may well reflect on different types of knowledge or domains. By examining domain-specific or even topic-specific personal epistemology, however, this source of variance is removed, making it less likely that any gender differences appear. Moreover, it should be noted that gender differences, in the favour of females, have most consistently been found on the dimensions of quick learning and fixed ability, respectively. The fact that those dimensions were not included in the framework on which we based our instrument, made it even less likely that any gender differences would be present in this study.

In previous studies, educational level (e.g., Perry 1970; Schommer et al. 1997; Wood and Kardash 2002) and expertise (e.g., Alexander and Dochy 1995; Kuhn 1991) have been found to be associated with personal epistemology. Because knowledge as well as interest seem to be essential aspects of increasing competence and expertise in a domain (Alexander 2004), we wanted to focus especially on the role of knowledge and interest in personal epistemology. At the same time, we wanted to measure both knowledge and interest at the same level of specificity as personal epistemology, that is, with particular reference to the topic of climate change. Presumably, students more knowledgeable about the topic would also be more likely to judge knowledge about climate change to be tentative and complex, as well as to be derived from multiple sources that would have to be compared and critically evaluated. Hence, more knowledgeable students would also display more sophisticated epistemic beliefs concerning knowledge and knowing in the area. However, with respect to topic interest, it seems possible to entertain two alternatives. First, one possibility is that students expressing higher personal interest in the topic would also be more likely to hold sophisticated beliefs about knowledge and knowing. Alternatively, another possibility is that students reporting higher levels of personal involvement and engagement in the topic, also would be more likely to attach values and feelings to it (Hidi 2001; Renninger 2000), and would be more prone to display some kind of one-sidedness or my-position bias with respect to epistemic beliefs. Consequentially, students high in topic interest could be more likely to hold more naïve topic-specific beliefs, for example, that there is only one correct answer to the issue of climate change, corresponding to their own position, and supported by experts in the area.

Given this theoretical background analysis, we set out to answer two questions in our investigation. First, does the US-based theoretical framework for personal epistemology set forth by Hofer and Pintrich (1997), including the dimensions of certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing, capture the dimensionality of topic-specific epistemic beliefs in Norwegian and Spanish university students? We expected that the four dimensions proposed by Hofer and Pintrich (1997) would be identified with the topic-specific measure that we used, but that there would also be some cultural variation in the dimensionality of epistemic beliefs concerning climate change. Some cultural variation was expected on the basis of previous, albeit domain-general, studies of the dimensionality of personal epistemology in different cultures, as well as the possibility that knowledge and knowing concerning climate change had been differently focused in both public debate and education in the northern and southern regions of Europe. Moreover, it could be argued that there is a strong anti-authoritarian strain in Norwegian culture, both in and out of school, which may manifest itself in an extensive skepticism to information stemming from agents of influence such as politicians, scientists, and the media (e.g., Barstad and Hellevik 2004; EU 2005). In contrast, Spanish culture seems to be characterized by stronger social conformity, at least among young people, with a tendency to uncritically accept information from authorities and the media (e.g., Digón 2003; Ministerio de Trabajo y Asuntos Sociales 2006). Taken together, such cultural differences between Norway and Spain made it highly relevant to compare differences between Norwegian and Spanish students with respect to personal epistemology in this investigation. Given the still exploratory nature of cross-cultural studies of personal epistemology (Maggioni et al. 2006), however, we did not have any specific hypotheses concerning how particular cultural traits would be related to dimensionality in personal epistemology. Also, because prior research on the dimensionality of topic-specific personal epistemology is essentially lacking, we considered it most appropriate to investigate the dimensionality of personal epistemology concerning a specific topic through exploratory rather than confirmatory factor analysis.

Second, to what extent are the variables of gender, topic knowledge, and topic interest, respectively, related to dimensions of personal epistemology? Based on previous research and theoretical assumptions referred to above, we did not expect any gender differences with respect to topic-specific epistemic beliefs in this study. However, in regard to topic knowledge, we expected that students more knowledgeable about the topic of climate change would also hold more sophisticated epistemic beliefs about the topic. Finally, the two possible results that we entertained with respect to topic interest and epistemic beliefs involved that higher interest in the topic of climate change could either be related to more sophisticated or to more naïve epistemic beliefs. Acknowledging the exploratory nature of this investigation of relationships among gender, topic knowledge, topic interest, and epistemic beliefs across cultures, we did not make any particular predictions regarding similarities and differences with respect to relationships among these variables in the two cultures.

2 Method

2.1 Participants and settings

The participants were 441 university students. Approximately half of the participants were Norwegians attending the University of Oslo; the other half were Spanish students enrolled in the University of Valencia and the Catholic University of Valencia, respectively. The Norwegian and Spanish participants were at comparable levels of postsecondary education, and all were enrolled in psychology or education courses.

Specifically, the Norwegian data were collected from 225 undergraduate students following an introductory course in educational science. The course was a mandatory course for students enrolled in three-year bachelor programs in education and special education, and it included the following four areas: philosophy of science and research methodology; learning and development; instruction, training, and Bildung[1]; and socialization and upbringing. Among the Norwegian participants, 81.3% were female and 18.7% were male, with an overall mean age of 22.9 (SD = 5.6). With very few exceptions, the students in this sample were white native-born Norwegians who had Norwegian as their first language and had completed their secondary education in a Norwegian school.

In Spain, 216 undergraduate students participated in the study. While 164 participants (139 from the University of Valencia and 35 from the Catholic University of Valencia) were following an introductory psychology course for students enrolled in a five-year program in psychology, 52 participants (from the University of Valencia) were enrolled in the introductory course of a three-year program for students pursuing a degree in preschool teaching. The last-mentioned course focused on preschool learning and development. The Spanish participants were 79.6% female and 20.4% male, with an overall mean age of 19.9 (SD = 4.9). Almost all the participants from Spain were white native-born Spaniards who had Spanish as their first language.

2.2 Materials

2.2.1 Topic knowledge measure

As a means of assessing students' prior knowledge about the topic of climate change, we developed a multiple-choice test composed of 17 items. The content of the items referred to concepts and information central to the issue of climate change, for example, the greenhouse effect, climate gases, and the Kyoto Protocol. Sample items from the topic knowledge measure are displayed in the Appendix. It should be noted that diverse aspects of the issue were covered by the topic knowledge measure, with items referring to both scientific (e.g., the greenhouse effect) and political (e.g., the Kyoto Protocol) aspects of the topic. A preliminary version of the topic knowledge measure

[1] The term Bildung is partly equivalent to the English term 'liberal education' but has stronger connotations to ideas about the education of character and the kind of personal growth that this implies (Standish 2003).

was reviewed by a climate researcher at the University of Oslo, with this resulting in only small modifications of the response alternatives of a couple of items.

We expected the participants' topic knowledge to vary substantially even though they had not formally studied the topic of climate change. Because climate change was discussed in newspapers and other media in both Norway and Spain, participants would have had a good opportunity to acquire knowledge about the topic.

Participants' topic knowledge score was a composite of the number of correct responses out of the 17 items. In Norway, the test-retest reliability of the scores on the topic-knowledge measure was computed in an independent sample of first-year education undergraduates ($n = 56$), with two weeks between the test and the retest. This yielded a reliability estimate (Pearson's r) of .77. In Spain, the test-retest reliability was .73 after two weeks in an independent sample of first-year psychology undergraduates ($n = 80$).

2.2.2 Topic interest measure

To measure participants' personal interest and engagement in issues and activities concerning climate change, we developed a 12-item measure, where participants indicated their level of interest or engagement by rating each item on a 10-point Likert-type scale ranging from *not at all true of me* (1) to *very true of me* (10). Half of the items allowed participants to express their interest in the topic without obligation, that is, without reporting any active engagement or involvement in addressing the problem of climate change (sample items: "I am interested in what conditions influence the Earth's climate"; "Global warming is an issue that interests me"). However, the other half of the items focused more on participants' active engagement and involvement in the issue, thus reflecting their willingness to act for the benefit of the Earth's climate (sample items: "I am concerned with how I myself can contribute to the reduction of environmental pollution"; "I try to convince others that we must reduce the discharges of climate gases").

To explore the underlying structure of this measure, the Norwegian and the Spanish data from the 12 interest items were separately submitted to a principal component analysis, using oblique rotation because we thought that potential components might be correlated. However, in both data sets, all the 12 items loaded on only one factor, with this indicating that topic interest as assessed by this measure was a unidimensional construct. Hence, we used a sum score based on all the 12 items to gauge participants' interest in the topic of climate change. In both Norway and Spain, scores on the topic interest measure yielded a reliability estimate (Cronbach's α) of .91.

2.2.3 Personal epistemology measure

To assess participants' personal epistemology concerning climate change, we designed the Topic-Specific Epistemic Beliefs Questionnaire (TSEBQ). The 49-item TSEBQ was based on Hofer and Pintrich's (1997) general theoretical model of personal epistemology (see above). Thus, we wrote items to assess two dimensions concerning knowledge about climate change (what one believes knowledge about climate change is like) and two dimensions concerning knowing about climate change (how one comes

to know about climate change). The 12 items written to assess beliefs concerning the certainty of knowledge about climate change focused on the degree to which participants considered knowledge about climate change to be tentative and evolving rather than true and certain (sample item: "The knowledge about issues concerning climate is consistently changing"). The 12 items written to assess beliefs concerning the simplicity of knowledge about climate change focused on the degree to which participants considered knowledge about climate change to consist of interrelated concepts and complex theories rather than an accumulation of specific facts and details (sample item: "Within climate research, various theories about the same will make things unnecessary complicated [reversed]"). The 12 items written to assess beliefs regarding the source of knowledge about climate change concerned to what extent participants considered the self to be a source and constructor of knowledge rather than viewing knowledge about climate change to be transmitted from experts (sample item: "With respect to climate problems, I feel I am on safe ground if I only find an expert statement [reversed]"). Finally, the 13 items written to assess beliefs concerning how knowledge claims about climate change can be justified or evaluated focused on the degree to which participants considered it necessary to use rules of inquiry or reason and to critically evaluate and compare sources rather than being content with what feels right or firsthand experience (sample item: "To check whether what I read about climate problems is reliable, I try to evaluate it in relation to other things I have learned about the topic").

The reason we decided to develop a new topic-specific instrument for measuring epistemic beliefs instead of just adapting an existing instrument, for example, Hofer's (2000) domain-specific questionnaire (DFEBQ), to the topic of climate change, was that the instruments that we scrutinized (including the DFEBQ) had not clearly identified the four dimensions of the Hofer and Pintrich (1997) framework in prior factor-analytic studies. In constructing the TSEBQ, we adapted items from a range of existing instruments, in particular from the domain-general questionnaires of Schommer (1990), Schraw et al. (2002), and Wood and Kardash (2002), the domain-specific questionnaires of Buehl et al. (2002), Hofer (2000), and Trautwein and Lüdtke (2007), and the Internet-Specific Epistemological Questionnaire of Bråten et al. (2005). We fastidiously adapted only items that seemed closely tied to a theoretical description of the dimension in question (Hofer and Pintrich 1997), also writing additional items that we agreed would be highly relevant to each of the four dimensions. For example, with respect to justification for knowing about climate change, we particularly drew on the items used by Bråten et al. (2005) to measure justification beliefs, but also adapted some items that fell on the justification factor in Hofer's (2000) study. With respect to source of knowledge about climate change, in addition to existing instruments mentioned above, we also drew on Schraw and Bruning's (1996) effort to measure readers' epistemologies of text (i.e., transmission and transactional beliefs) when constructing the TSEBQ.

The participants were given the following written direction for the TSEBQ: "Issues concerning climate are highly topical and often mentioned in the media. We can read daily about issues such as climate change, pollution of the atmosphere, global warming, extreme weather, rise in ocean levels, and melting of ice in polar regions. This is material that we often encounter in newspapers and magazines, as well as on TV and

radio. Most people who do research on climate have a background in natural science, for example in chemistry, biology, or meteorology. The following questions concern knowledge about climate and how one comes to know about climate. There are no right or wrong answers to these questions; it is your personal beliefs that interest us. Use the scale below to answer the questions. If you strongly agree with a statement, circle 10; if you strongly disagree, circle 1. If you more or less agree with a statement, circle the number between 1 and 10 that best expresses your belief." Higher scores on the TSEBQ-items were supposed to reflect more sophisticated epistemic beliefs. Therefore, the ratings of the items that were negatively worded were reversed before any statistical analyses were conducted.

It should be noted that the TSEBQ was not topic-specific in the sense that the items could not be adapted to another topic by replacing climate change with that topic. Rather, our approach parallels research on domain-specific beliefs, where more general questions have been applied to a particular domain to allow comparisons of epistemic beliefs across domains (Hofer 2006). In the same way, the TSEBQ could be adapted to different topics when examining stability and variation in epistemic beliefs across topics. Because our measures of topic knowledge and topic interest, respectively, contained items referring to different aspects of climate change (e.g., the greenhouse effect, climate gases), it could be argued that those measures were even more specific than the TSEBQ. Of course, this variation follows from the nature of the measures themselves, with asking a whole series of multiple-choice questions about climate change or asking people to rate their interest in climate change over and over again is clearly not practical. However, while we utilized questions that could be adapted to other topics than climate change in the TSEBQ, we also took care to further specify various aspects related to climate change in the written direction for the inventory (see above).

We chose to target personal epistemology concerning climate change in the present study for several reasons. First, climate change is an expanding area of research, where knowledge is growing but still characterized by many open questions and conflicting scientific evidence. Second, the knowledge base for conclusions regarding climate change is publicly debated, at least in developed democratic societies, as are the methods used to build knowledge in the area. Third, climate change is an issue of vital importance with strong individual and social implications. Because topics concerning unsettled or controversial issues that are also related to people's health or safety may be particularly well suited to elicit epistemic thinking (Kolstø 2001; Jungermann et al. 1996), we expected that the participants in both countries had reflected somewhat on the issue of climate change and developed a personal stance on the nature of knowledge and knowing in the area.

2.3 Procedure

All the measures were group administered to the participants during regular lectures in the beginning of the autumn term. In Norway, the two Norwegian authors and three trained research assistants collected the data from all the Norwegian participants during one lecture; in Spain, the two Spanish authors collected the data from the

participants during three lectures, with 129, 35, and 52 participants, respectively, attending each lecture. The administration of the measures followed the same protocol in Norway and in Spain. Each participant received a folder with a demographic information sheet followed by three questionnaires in this order: (a) topic knowledge measure, (b) topic interest measure, and (c) personal epistemology measure. The participants were orally instructed that they should complete the questionnaires in the order they were presented in the folder. They were also asked to pay close attention to the written instruction at the beginning of each questionnaire. The participants were allowed as much time as they needed to complete the demographic information sheet and the questionnaires, and everyone finished within one lecture period of 45 min.

All three questionnaires were initially developed in Norwegian by the two Norwegian authors in collaboration with Marit Samuelstuen. To prepare the Spanish versions, several steps were taken. First, the first author, fluent in Norwegian and English, translated the measures into English. The preliminary English versions were collectively reviewed by the four authors, all proficient in English (and two of them native Norwegian speakers), and later revised on the basis of this discussion. Next, one of the Spanish authors translated the measures from English to Spanish, with this translation reviewed by the other Spanish author and disagreements concerning the comparability of the versions solved through discussion. In translating into Spanish, the Spanish authors took great care to retain the accurate meaning of the items, and to make them easy to understand in the cultural context of the Spanish participants. Finally, a professor of English at the University of Valencia independently compared the English and the Spanish versions of the questionnaires and, on the basis of this, suggested some revisions of the Spanish translations that were taken into account.

3 Results

3.1 Factor analyses

The first research question, concerning the dimensionality of topic-specific personal epistemology, was addressed through principal-components factor analyses of the scores on the TSEBQ. We conducted separate factor analyses of the personal epistemology data for the Norwegian and Spanish participants, with this allowing us to explore the consistency of emerging factor solutions across cultural contexts. In the following, we first present the factor analyses with the Norwegian participants and then report on the factor analyses with the Spanish participants.

3.1.1 Norwegian participants

Prior to factor analyzing the data, we computed the internal consistency for the 49 items of the TSEBQ. Coefficient α was .74, with item—total correlations ranging from −.22 to .48. Seven items had negative item—total correlations, and six items had item—total correlations less than .10. Following Wood and Kardash (2002), we did not find it reasonable that some items should be unrelated or even negatively related to other items used to assess personal epistemology, and therefore

eliminated those 13 items from further analysis, with this procedure also consistent with Hofer and Pintrich's (1997) idea about the multidimensional but still theory-like, interrelated nature of epistemic beliefs (see also, Hofer 2004c). When we re-ran the reliability for the 36-item scale, a coefficient α of .82 was obtained. Next, principal component analysis was performed on the 36 items. Because we expected the factors to be correlated, we chose to conduct oblique rotation.

Although initial analysis showed that 10 factors met the Kaiser—Guttman retention criteria of eigenvalues greater than unity, with these factors explaining 58.1% of the total sample variation, inspection of the scree plot indicated a four-factor solution consisting of one large factor with an eigenvalue of 5.32 and three other factors with eigenvalues greater than 2. The remaining six factors had eigenvalues ranging from 1.71 to 1.10. Both the size of the eigenvalues and the scree plot appeared consonant with a four-factor solution and, hence, we decided to examine this solution further. First, a four-factor solution was forced, with a principal component analysis with oblique rotation performed on all 36 items. After this analysis, 10 items were eliminated because they did not load at least .35 on any of the four factors or because they loaded significantly or equally on more than one factor. When a four-factor solution was forced for a second time, using the same procedure on the remaining 26 items, four factors with high loadings (>.40) and no overlap for any item were identified after eliminating two items loading on more than one factor. Thus, this four-factor solution included 24 items of the TSEBQ. The four factors had eigenvalues from 4.06 to 1.75 and explained 40.3% of the total sample variation. In accordance with Hofer and Pintrich's (1997) general model, the four factors were labelled: Certainty of Knowledge About Climate Change, Simplicity of Knowledge About Climate Change, Source of Knowledge About Climate Change, and Justification for Knowing About Climate Change. The items assigned to each factor, as well as item-to-factor loadings and eigenvalues for each factor, are shown in Table 1.

The six items assigned to Certainty of Knowledge About Climate Change focus on the tentativeness and ambiguity of knowledge about climate change. All the items were originally written to assess the certainty dimension. High scores on this factor represent the belief that knowledge about climate change is provisional and ambiguous, and low scores represent the belief that knowledge about climate change is permanent and unambiguous.

The six items comprising Simplicity of Knowledge About Climate Change deal with the structure of knowledge about climate change, with four of these items originally written to assess the simplicity dimension and the two others written to assess certainty of knowledge and justification for knowing, respectively. High scores on this factor represent the view that knowledge about climate change is theoretical and complex, and low scores represent the view that knowledge about climate change consists of a loose collection of proven facts.

The five items comprising Source of Knowledge About Climate Change focus on where knowledge about climate change resides, with four of these items originally written to assess the source dimension and one item written to assess justification for knowing. High scores on this factor reflect the belief that personal judgments and interpretations are main sources of knowledge about climate change, and low scores

Table 1 Factor analysis of the Topic-Specific Epistemic Beliefs Questionnaire—Norwegian participants

Variables	Factor loadings			
	Certainty	Simplicity	Source	Justification
What is considered to be certain knowledge about climate today, may be considered to be false tomorrow	.64			
Certain knowledge about climate is rare	.64			
The results of climate research are preliminary	.62			
Theories about climate can be disproved at any time	.61			
The knowledge about issues concerning climate is constantly changing	.59			
Problems within climate research do not have any clear and unambiguous solution	.55			
Certainty Eigenvalue = 2.66				
With respect to knowledge about climate, there are seldom connections among different issues (R)		.60		
Within climate research, accurate knowledge about details is the most important (R)		.59		
Within climate research, various theories about the same will make things unnecessary complicated (R)		.57		
Knowledge about climate is primarily characterized by a large amount of detailed information (R)		.56		
The knowledge about climate problems is indisputable (R)		.48		
There is really no method I can use to decide whether claims in texts about issues concerning climate can be trusted (R)		.43		
Simplicity Eigenvalue = 1.75				
I often feel that I just have to accept that what I read about climate problems can be trusted (R)			.71	
When I read about issues concerning climate, the author's opinion is more important than mine (R)			.69	
With respect to climate problems, I feel I am on safe ground if I only find an expert statement (R)			.65	
When I read about climate problems, I only stick to what the text expresses (R)			.57	
My personal judgments about climate problems have little value compared to what I can learn about them from books and articles (R)			.52	
Source Eigenvalue = 2.00				
To check whether what I read about climate problems is reliable, I try to evaluate it in relation to other things I have learned about the topic				.79
When I read about issues related to climate, I try to form my own understanding of the content				.77
To gain real insight into issues related to climate, one has to form one's own personal opinion of what one reads				.59
When I read about issues concerning climate, I evaluate whether the content seems logical				.51
To be able to trust knowledge claims in texts about issues concerning climate, one has to check various knowledge sources				.44

Table 1 continued

Variables	Factor loadings			
	Certainty	Simplicity	Source	Justification
Within climate research, there are connections among many topics				.43
I understand issues related to climate better when I think through them myself, and not only read about them				.41
Justification Eigenvalue = 4.06				

Note: (R) = Reversed

reflect the belief that one should only rely on expert authors when reading about climate change.

Finally, the seven items assigned to Justification for Knowing About Climate Change concern how the trustworthiness of knowledge claims about climate change can be evaluated. Three of these items were initially written to assess justification for knowing, three items were written to assess source of knowledge, and one item was written to assess simplicity of knowledge. High scores on this factor reflect the idea that knowledge claims about climate change should be evaluated through independent, critical and logical thinking, as well as through the comparison of multiple related sources, and low scores represent a rejection of the notion that knowledge claims need to be checked against reason or other sources. Presumably, the reason the three items written to assess source of knowledge loaded on this factor was that, in addition to other sources, students considered their own thinking to be a relevant source when evaluating knowledge claims about climate change. The item written to assess the simplicity dimension probably loaded on this factor because students considered the multiple sources they could draw upon when evaluating knowledge claims to be interconnected rather than isolated.

We also examined the reliabilities for the four factors emerging from the Norwegian TSEBQ-data. Cronbach's α for items loading on Certainty of Knowledge About Climate Change, Simplicity of Knowledge About Climate Change, Source of Knowledge About Climate Change, and Justification for Knowing About Climate Change were .70, .60, .71, and .71, respectively.

3.1.2 Spanish participants

The Spanish TSEBQ-data were analyzed with exactly the same procedure as were the Norwegian data. The computation of the internal consistency for all 49 items yielded a coefficient α of .68, with item—total correlations ranging from −.13 to .43. Seven items had negative item—total correlations, and eight items had item—total correlations less than .10. Coefficient α computed after the elimination of these 15 items was .81. Initial principal component analysis with oblique rotation on the remaining 34 items yielded 10 factors with eigenvalues greater than 1 that explained 62.2% of the total sample variation. However, inspection of the scree plot suggested a four-factor solution with one large factor with an eigenvalue of 5.04 and three other factors with

eigenvalues ranging from 3.67 to 2.27. The remaining six factors had eigenvalues ranging from 1.49 to 1.06. Because both the size of the eigenvalues and the scree plot suggested a four-factor solution, we then forced a four-factor solution on all 34 items. After this analysis, four more items were eliminated because they loaded significantly or equally on more than one factor. When a four-factor solution was forced for a second time on the remaining 30 items, four factors with high loadings (>.37) and no overlap for any item were identified after eliminating one item loading on more than one factor. Thus, this solution included 29 items, which fell on four factors with eigenvalues ranging from 4.52 to 1.98, explaining 41.5 % of the total sample variation. The four

Table 2 Factor analysis of the Topic-Specific Epistemic Beliefs Questionnaire—Spanish participants

Variables	Factor loadings			
	Certainty tentativeness	Certainty ambiguity	Source	Justification
What is considered to be certain knowledge about climate today, may be considered to be false tomorrow	.81			
The only thing we know for certain about climate problems, is that nothing is certain	.77			
The results of climate research are preliminary	.74			
Theories about climate can be disproved at any time	.63			
Certain knowledge about climate is rare	.57			
The knowledge about issues concerning climate is constantly changing	.56			
Certainty—Tentativeness Eigenvalue = 4.52				
With respect to knowledge about climate, there are seldom connections among different issues (R)		.66		
Within climate research, there is agreement about what is true (R)		.64		
Research on climate shows that most problems in the area have a correct answer (R)		.52		
The knowledge about climate problems is indisputable (R)		.46		
With respect to issues concerning climate, that the viewpoints are good is more important to me than how one has arrived at them (R)		.46		
Knowledge about climate is primarily characterized by a large amount of detailed information (R)		.44		
Certainty—Ambiguity Eigenvalue = 1.98				
With respect to climate problems, I feel I am on safe ground if I only find an expert statement (R)			.69	
When I read about climate problems, I only stick to what the text expresses (R)			.65	
I often feel that I just have to accept that what I read about climate problems can be trusted (R)			.65	
When I read about issues concerning climate, the author's opinion is more important than mine (R)			.57	
My personal judgments about climate problems have little value compared to what I can learn about them from books and articles (R)			.55	

Table 2 continued

Variables	Factor loadings			
	Certainty tentativeness	Certainty ambiguity	Source	Justification
Ordinary people have no basis for speaking about issues concerning climate (R)			.49	
To understand climate problems, it is not sufficient only to read what experts have written about them			.45	
I understand issues related to climate better when I think through them myself, and not only read about them			.38	
Climate researcher can find the truth about almost everything concerning climate (R)			.37	
Source Eigenvalue =3.41				
To check whether what I read about climate problems is reliable, I try to evaluate it in relation to other things I have learned about the topic				.73
When I read about issues related to climate, I try to form my own understanding of the content				.73
To find out whether what I read about climate problems is trustworthy, I try to compare knowledge from multiple sources				.69
Within climate research, there are connections among many topics				.67
When I read about issues concerning climate, I evaluate whether the content seems logical				.63
Within climate research, many things hang together				.62
Within climate research, knowledge is complex				.43
To be able to trust knowledge claims in texts about issues concerning climate, one has to check various knowledge sources				.39
Justification Eigenvalue = 2.54				

Note: (R) = Reversed

factors were labelled: Certainty of Knowledge About Climate Change—Tentativeness, Certainty of Knowledge About Climate Change—Ambiguity, Source of Knowledge About Climate Change, and Justification for Knowing About Climate Change. The items assigned to each factor, item-to-factor loadings, and eigenvalues are shown in Table 2.

The six items assigned to Certainty of Knowledge About Climate Change—Tentativeness focus on the possibility to obtain permanent or stable knowledge about climate change. All six items were originally written to assess the certainty dimension, and five of them were also included in the certainty dimension identified with Norwegian participants. While high scores on this factor represent the belief that knowledge about climate change is only provisional, low scores represent the belief that knowledge about climate change is permanent.

The six items comprising Certainty of Knowledge About Climate Change—Ambiguity focus on the possibility to obtain unambiguous and unconditional knowledge about climate change. Three of these items were originally written to assess the

certainty dimension, two were written to assess the simplicity dimension, and one was written to assess justification for knowing. High scores on this factor represent the view that knowledge about climate change is ambiguous and conditional, and low scores represent the belief that knowledge about climate change consists of unambiguous and unconditional truths.

The nine items assigned to Source of Knowledge About Climate Change concern beliefs about where knowledge about climate change originates or resides. Seven of these items were originally written to assess the source dimension; the two others were written to assess the certainty and the justification dimension, respectively. Six of the items were common to the source dimensions identified with Norwegian and Spanish participants. While high scores on this factor reflect the belief that personal judgments and interpretations are main sources of knowledge about climate change, low scores represent the view that knowledge resides in outside expertise, from which it is transmitted via reading.

Finally, the eight items comprising Justification for Knowing About Climate Change focus on the evaluation of the trustworthiness of knowledge claims concerning climate change. Four of these items were originally written to assess the justification dimension, three were written to assess simplicity of knowledge, and one was written to assess source of knowledge. Five of the items were common to the justification factor identified with Norwegian and Spanish participants. High scores on this factor represent the view that knowledge claims about climate change should be evaluated through independent logical thinking, as well as through the comparison of multiple related or connected sources, and low scores represent a rejection of the idea that knowledge claims in the area need to be evaluated through reason or comparison of related sources. The reason the three items written to assess the simplicity dimension loaded on this factor was probably that the students emphasized the interconnected nature of the sources they could draw upon when evaluating knowledge claims about climate change. The loading of the item written to assess source of knowledge on this factor probably meant that the students believed that their own thinking was also a relevant source when evaluating knowledge claims.

The reliability estimates (Cronbach's α) for the items loading on the Certainty of Knowledge About Climate Change—Tentativeness, Certainty of Knowledge About Climate Change—Ambiguity, Source of Knowledge About Climate Change, and Justification for Knowing About Climate Change factors were .80, .60, .72, and .79, respectively.

3.2 Multiple regression analyses

The other research question, concerning the relationship of topic-specific epistemic beliefs with other variables, was addressed by performing four hierarchical multiple regression analyses for each sample, with the measures resulting from our factor analyses used as dependent variables in these analyses. In each analysis, gender was entered into the equation in step one. In addition, age was included as a predictor to control for any age differences in personal epistemology. In step two, we included topic

Table 3 Descriptive statistics for variables included in hierarchical regression analyses

Variable	Norwegian participants			Spanish participants		
	M	SD	Skewness	*M*	SD	Skewness
Topic knowledge	7.24	2.41	.16	5.88	2.38	.38
Topic interest	4.89	1.77	.43	6.05	1.63	.03
Certainty beliefs	6.73	1.52	−.13			
Simplicity beliefs	6.56	1.33	−.27			
Source beliefs	5.95	1.66	−.25			
Justification beliefs	6.75	1.42	−.16			
Certainty—Tentativeness				5.95	1.57	.09
Certainty—Ambiguity				6.24	1.22	.02
Source beliefs				5.72	1.25	−.07
Justification beliefs				7.08	1.28	−.19

Table 4 Results of hierarchical regression analyses for variables predicting certainty and simplicity beliefs among Norwegian participants

Variable	Certainty beliefs			Simplicity beliefs		
	B	SE *B*	*β*	*B*	SE *B*	*β*
Step 1						
Gender	−.17	.26	−.04	−.01	.24	.00
Age	.00	.02	−.02	−.02	.02	−.09
Step 2						
Gender	−.16	.27	−.04	.05	.24	.01
Age	.00	.02	−.01	−.03	.02	−.11
Topic knowledge	.05	.05	.07	.05	.04	.09
Topic interest	−.06	.06	−.06	.04	.06	.05

Note: For certainty beliefs: $R^2 = .002$ for step 1 (*ns*), $\Delta R^2 = .007$ for step 2 (*ns*); for simplicity beliefs: $R^2\, p = 009$ for step 1 (*ns*), ΔR^2=.012 for step 2 (*ns*)

knowledge and topic interest. Deletion of missing values resulted in 217 Norwegian participants available for the regression analyses.

Descriptive statistics (means, standard deviations, and coefficients of skewness) for predictors and outcome measures are shown for both samples in Table 3. These data indicated that all score distributions were approximately normal and, thus, appropriate for use in parametric statistical analyses.

3.2.1 Norwegian participants

Table 4 shows the results of the hierarchical regression analysis for Certainty of Knowledge About Climate Change as well as that for Simplicity of Knowledge About Climate Change. In neither case did gender and age together explain a statistically

Table 5 Results of hierarchical regression analyses for variables predicting source and justification beliefs among Norwegian participants

Variable	Source beliefs			Justification beliefs		
	B	SE *B*	β	*B*	SE *B*	β
Step 1						
Gender	.04	.21	.01	−.24	.25	−.07
Age	−.01	.02	−.04	.02	.02	.08
Step 2						
Gender	.16	.20	.05	−.06	.23	−.02
Age	−.02	.01	−.11	.00	.02	.00
Topic knowledge	.00	.03	.00	.02	.04	.04
Topic interest	.26	.05	.38***	.35	.05	.43***

Note: For source beliefs: $R^2 = .002$ for step 1 (*ns*), $\Delta R^2 = .14$ for step 2 ($p < .001$); for justification beliefs: $R^2 = .01$ for step 1 (*ns*), $\Delta R^2 = .19$ for step 2 ($p < .001$). *** $p < .001$

significant amount of the variance in epistemic beliefs concerning climate change after step one, $R^2 = .002$, $F_{\text{change}}(2, 214) = .23$, *ns* for the certainty factor, $R^2 = .009$, $F_{\text{change}}(2, 214) = .94$, *ns* for the simplicity factor. After step two, with topic knowledge and topic interest also included in the equation, $R^2 = .009$, $F_{\text{change}}(2, 212) = .73$, *ns* for the certainty factor, $R^2 = .012$, $F_{\text{change}}(2, 212) = 1.32$, *ns* for the simplicity factor. Thus, in neither case did the addition of topic knowledge and topic interest result in a statistically significant increment in R^2.

The results of the hierarchical regression analyses for variables predicting Source of Knowledge About Climate Change and Justification for Knowing About Climate Change, respectively, are shown in Table 5. After step one, with gender and age in the equation, $R^2 = .002$, $F_{\text{change}}(2, 214) = .23$, *ns* for the source factor. After step two, with topic knowledge and topic interest added to prediction of source beliefs by gender and age, $R^2 = .14$, $F_{\text{change}}(2, 212) = 16.87$, $p = .000$. Thus, addition of topic knowledge and topic interest to the equation resulted in a statistically significant increment in R^2. Topic interest positively predicted source beliefs, $\beta = .38$, $p = .000$, with this indicating that participants more interested in the topic of climate change were also holding more sophisticated beliefs about knowing in the area. With respect to Justification for Knowing About Climate Change, gender and age did not account for a statistically significant proportion of the variance after step one, $R^2 = .01$, $F_{\text{change}}(2, 214) = 1.12$, *ns*. However, the variables entered in step two accounted for additional variance, with $R^2 = .20$, $F_{\text{change}}(2, 212) = 25.22$, $p = .000$ after step two. A statistically significant positive relationship was found for topic interest, $\beta = .43$, $p = .000$, with this indicating that high-interest participants were more likely to hold sophisticated beliefs concerning the justification of knowledge claims.

3.2.2 Spanish participants

Table 6 shows the results of the hierarchical regression analyses for the two certainty factors. After step one, with gender and age in the equation, $R^2 = .021$, F_{change}

Table 6 Results of hierarchical regression analyses for variables predicting certainty—tentativeness and certainty—ambiguity beliefs among Spanish participants

Variable	Certainty—Tentativeness			Certainty—Ambiguity		
	B	SE *B*	β	*B*	SE *B*	β
Step 1						
Gender	.14	.26	.04	.03	.20	.01
Age	−.05	.02	−.14*	−.05	.02	−.18*
Step 2						
Gender	.21	.27	.05	.15	.20	.05
Age	−.04	.02	−.13	−.04	.02	−.13*
Topic knowledge	.07	.05	.10	.12	.04	.23**
Topic interest	.00	.01	−.03	−.01	.00	−.16*

Note: For certainty-tentativeness beliefs: $R^2 = .021$ for step 1 (*ns*), $\Delta R^2 = .009$ for step 2 (*ns*); for certainty—ambiguity beliefs: $R^2 = .031$ for step 1 ($p < .05$), $\Delta R^2 = .056$ for step 2 ($p < .01$). * $p < .05$, ** $p < .01$

(2, 213)= 2.32, *ns* for Certainty of Knowledge About Climate Change—Tentativeness. In this analysis, the addition of topic knowledge and topic interest in step two did not result in a statistically significant increment in R^2, with $R^2 = .030$, $F_{\text{change}}(2, 211) = .93$, *ns* after step two. With respect to Certainty of Knowledge About Climate Change—Ambiguity, $R^2 = .031$, $F_{\text{change}}(2, 213) = 3.39$, $p = .036$ after step one. In this step, age was a negative predictor of participants' certainty beliefs, $\beta = -.18$, $p = .01$. After addition of topic knowledge and topic interest in step two, $R^2 = .087$, $F_{\text{change}}(2, 211) = 6.50$, $p = .002$. Topic knowledge positively predicted certainty beliefs, $\beta = .23$, $p = .001$, whereas topic interest negatively predicted them, $\beta = -.16$, $p = .020$. Thus, more knowledgeable participants were more likely to believe that knowledge about climate change is ambiguous and conditional, whereas more interested participants were more likely to believe that there is only one correct answer to this issue.

The results of the hierarchical regression analyses for variables predicting Source of Knowledge About Climate Change and Justification for Knowing About Climate Change, respectively, are shown in Table 7. After step one, with gender and age in the equation, $R^2 = .034$, $F_{\text{change}}(2, 213) = 3.76$, $p = .025$ for the source factor. In this step, age was a negative predictor of source beliefs, $\beta = -.17$, $p = .015$. After step two, with topic knowledge and topic interest added to the prediction of source beliefs, $R^2 = .090$, $F_{\text{change}}(2, 211) = 6.52$, $p = .002$. Again, topic knowledge was a positive predictor, $\beta = .23$, $p = .001$, whereas topic interest was a negative predictor, $\beta = -.15$, $p = .026$, with this indicating that high knowledgeable students were more likely than low knowledgeable students to view themselves as important sources of knowledge about climate change, whereas high-interest students were more likely than low-interest students to believe that knowledge about climate change resides in outside expertise. With respect to Justification for Knowing About Climate Change, gender and age together did not explain a statistically significant amount of the variance after

Table 7 Results of hierarchical regression analyses for variables predicting source and justification beliefs among Spanish participants

Variable	Source beliefs			Justification beliefs		
	B	SE *B*	*β*	*B*	SE *B*	*β*
Step 1						
Gender	.26	.21	.09	−1.18	1.73	−.05
Age	−.04	.02	−.17*	.02	.15	.01
Step 2						
Gender	.39	.21	.13	−1.38	1.60	−.05
Age	−.03	.02	−.12	−.03	.14	−.02
Topic knowledge	.12	.04	.24**	.02	.29	.00
Topic interest	−.01	.00	−.15*	.22	.03	.42***

Note: For source beliefs: $R^2 = .034$ for step 1 ($p < .05$), $\Delta R^2 = .056$ for step 2 ($p < .01$); for justification beliefs: $R^2 = .002$ for step 1 (*ns*), $\Delta R^2 = .18$ for step 2 ($p < .001$). * $p < .05$, ** $p < .001$, *** $p < .001$

step one, $R^2 = .002$, $F_{\text{change}}(2,\ 213) = .24$, *ns*. After step two, with topic knowledge and topic interest also included in the equation, $R^2 = .18$, $F_{\text{change}}(2,\ 211) = 23.07$, $p = .000$. Topic interest positively predicted beliefs about justification for knowing, $\beta = .42$, $p = .000$, with this indicating that the more interested participants were in the topic, the more they believed that knowledge claims about climate change should be evaluated through critical reasoning and comparison of multiple knowledge sources.

4 Discussion

The present research contributes to the literature on personal epistemology by presenting new findings concerning the dimensionality of topic-specific epistemic beliefs across cultures. First, our findings corroborate prior research focusing on domain-general and domain-specific levels by demonstrating the complex and multidimensional nature of epistemic beliefs even at the level of topic-specificity. Moreover, the factor analyses of the TSEBQ-scores that we conducted with Norwegian and Spanish participants indicated that the dimensionality of topic-specific personal epistemology was captured quite well by the categories included in Hofer and Pintrich's (1997) general theoretical model. That is, all four factors emerging from the Norwegian data corresponded to dimensions described by Hofer and Pintrich. In addition, three of these dimensions, concerning the certainty and source of knowledge as well as justification for knowing, were also identified in the Spanish data. The reliability estimates for the factors obtained in both samples indicated that statistically sound measures could be constructed on the basis of the factors. Taken together, this suggests that the theoretical framework proposed by Hofer and Pintrich (1997) is appropriate for quantitatively studying personal epistemology on a topic-specific level.

The reason other researchers conducting factor analyses of epistemic belief data on a topic-specific level have not identified the four dimensions proposed by Hofer and Pintrich (1997) could be that most of those studies have used a semantic differential

assessing associative-connotative aspects of personal epistemology (Kienhues et al. 2008; Pieschl et al. 2008; Stahl and Bromme 2007). Moreover, that Kienhues et al. did not identify the four dimensions when using Hofer's (2000) DFEBQ adapted to the topic of genetics is not surprising given that Hofer (2000) did also not identify those dimensions when using the domain-specific version of her instrument. In fact, that was one of our reasons for developing a new instrument for measuring topic-specific epistemic beliefs instead of adapting the DFEBQ to the topic in question (see Sect. 2.2).

Second, our cross-cultural comparison of the structure of the TSEBQ-data draws attention to the cultural embeddedness of topic-specific epistemic beliefs. Thus, even though considerable cross-cultural generalizability in dimensionality was demonstrated, with certainty, source, and justification dimensions identified in both Norway and Spain, there were also some notable differences between the two contexts. Specifically, beliefs about the simplicity of knowledge did not emerge as a distinct factor from the Spanish data, where, instead, beliefs about the certainty of knowledge split into two factors, one focusing on the tentativeness of knowledge and the other on the ambiguity of knowledge. Apparently, beliefs about the certainty of knowledge were particularly salient and important epistemic beliefs concerning climate change among the Spanish participants. While the exact reason why simplicity beliefs may be more evident within the Norwegian cultural context and certainty beliefs more evident within the Spanish cultural context can only be discovered through further research, such cultural differences might be related to a different emphasis thus far given to the topic of climate change in Northern and in Southern Europe. For example, because the negative consequences of global warming are supposed to be most pronounced in the northerly regions, the issue has been heatedly debated there by scientists, politicians, business and labor union leaders, and others for quite some time, with this possibly making issues concerning the complexity or simplicity of knowledge in the area more salient. At the same time, public debate about the issue in Spain may have focused more on the certainty aspect of knowledge about climate change, with questions concerning the stability and accuracy of such knowledge placing certainty beliefs in the forefront of students' minds. In any case, the fact that the two samples were from comparable student populations in Norway and Spain strengthens the assumption that cultural variables were at the root of observed differences in the dimensionality of epistemic beliefs.

It should be noted, however, that there were also differences in the specific contents and instructional practices that the two samples experienced, with this, possibly, influencing participants' epistemic beliefs. For example, the data for the Norwegian participants were collected during a course that included philosophy of science and research methodology, which might have increased their awareness of epistemic beliefs. One possible approach is to view this as a puzzle and try to disentangle the roles played by culture on the one hand and course content and instructional practice on the other by comparing students across cultures who are taught the same content in the same way, should such students really exist. We would argue, however, that a more reasonable approach is to view such differences in academic context as an inherent part of cultural differences. That said, it should be acknowledged that our study can not determine what precisely it is about the cultures that may create the observed differences in the dimensionality of epistemic beliefs. With respect to assessment, such

differences, whatever the reason, raise the question of whether methods and instruments for assessing personal epistemology needs to be adapted to specific cultures (cf., Bråten and Strømsø 2005), a question that can only be answered through much further international cooperation in the area of personal epistemology (Maggioni et al. 2006).

Third, our regression of topic-specific epistemic beliefs on gender, topic knowledge, and topic interest also revealed some interesting similarities and differences across cultures. As expected, gender did not predict epistemic beliefs concerning climate change in any of the samples, with this consistent with the view that gender differences may be more pronounced when domain-general personal epistemology is assessed (Buehl et al. 2002). In regard to topic knowledge, this variable differentially predicted epistemic beliefs across cultures, with scores on two of the belief dimensions positively predicted by topic knowledge among the Spanish participants but no relationships found for topic knowledge among the Norwegians. Thus, while the positive relationships between topic knowledge and epistemic beliefs among the Spanish participants were consistent with our expectations, with more knowledgeable participants also more likely to hold sophisticated beliefs about knowledge and knowing, topic knowledge did not consistently predict epistemic beliefs, neither across nor within cultures, in this study. In regard to topic interest, we noted that this variable was a more consistent predictor of epistemic beliefs across cultures than was topic knowledge, with scores on two belief dimensions predicted by topic interest among the Norwegian participants and three dimensions predicted among the Spanish participants. However, whereas topic interest was only a positive predictor among the Norwegians, it was both a positive and a negative predictor among the Spanish participants. In particular, the fact that high-interest Spanish students were more likely to hold naïve beliefs concerning certainty as well as source of knowledge gave us a pause. Taking into consideration the generally low level of topic knowledge among the Spanish participants[2], this suggests that high topic interest in combination with insufficient topic knowledge may actually be maladaptive, for example, by leading people to view the issue in black and white and to seek support in external authority for their view. In terms of education, this suggests that high interest or enthusiasm without much knowledge about the topic should be cognitively tempered or canalized into more adaptive epistemic thinking by providing students with relevant background knowledge, for instance through readings or informed discussions about the issue. At the same time, however, topic interest was a strong positive predictor of scores on the justification for knowing dimension in both Norway and Spain, with this being consistent with the view that personal interest may serve to motivate strategic effort to think deeply about and monitor the understanding of information (cf., Krapp 1999; Schiefele 1998, 1999). Given the preliminary nature of our findings, as well as the important consequences personal epistemology may have when people try to understand a complex scientific topic such as climate change by studying multiple, even conflicting, information sources on the issue (Bråten 2008), it is a great challenge for

[2] Please note that the level of topic knowledge among the Spanish participants ($M = 5.88$) was also statistically significantly lower than the level of topic knowledge among the Norwegian participants ($M = 7.24$), with $t(441) = 5.81$, $p = .000$.

future researchers to gain a better understanding of the factors that may constrain or enhance adaptive topic-specific epistemic beliefs in particular cultures.

Although age was not focused upon in the theoretical framework of the study, we included this variable as a suitable control and found that in the Spanish sample, age was a negative predictor of three of the belief dimensions, indicating that younger students were more likely to hold sophisticated beliefs about climate change than were older students. There are a couple of possible reasons for this interesting finding, which runs counter to theory and research grounded in developmental psychology (e.g., King and Kitchener 2004; Kuhn and Weinstock 2002). One reason may be that younger Spanish students were likely to have more knowledge about climate change than older Spanish students,[3] possibly because they had more recently learnt about the topic as part of the high school curriculum. It is also conceivable, however, that younger students were more inclined to respond to the topic-specific epistemology items in the socially desired direction, with this resulting in more sophisticated beliefs among those students than among older ones.

Some limitations with the present study are important to mention. One concerns the way we chose to measure epistemic beliefs. The reason we used questionnaires with Likert-type scales was the suitability of this approach for conducting large-scale factor-analytic studies involving hundreds of participants, as well as our wish to compare our results with those of other studies using the same methodology. However, one consequence of our choice was that the dimensions that were identified in the two samples were limited by the content of the questionnaire and, thus, we cannot be sure that we were assessing and comparing all relevant dimensions of topic-specific personal epistemology across cultures. In other words, our methodology restricted participants' reports of epistemic beliefs to beliefs prelisted on the questionnaire even though they may have held other beliefs about the topic. Moreover, there are several other issues with using questionnaires and Likert-type rating scales to measure epistemic beliefs, such as whether those scales can adequately capture the highest level of sophistication involving a reconciliation or coordination of objectivity and subjectivity (e.g., Kuhn and Weinstock 2002). Thus, it should be acknowledged that our methodology may have led us to compare a particular type or range of epistemic beliefs. Given such issues, future cross-cultural research on personal epistemology would probably profit from smaller-scale studies using more qualitative, dynamic assessments (cf., Schraw and Sinatra 2004), at least in an initial phase where potential cross-cultural similarities and differences in the structure and nature of epistemic beliefs are explored (Bråten and Strømsø 2005). Moreover, multi-methods approaches combining quantitative and qualitative data sources may be valuable when assessing personal epistemology across cultures. For example, combining the use of questionnaires with in-depth interviewing about how individual items are understood in different cultures may lead to the development of more culturally sensitive measures, as well as to a triangulation of data allowing for a more complete picture of epistemic beliefs across cultures.

Another limitation of this study is that we cannot claim that our findings generalize to the whole student population in the respective countries, or even to the population

[3] Whereas age and topic knowledge were unrelated in the Norwegian sample, a statistically significant negative correlation ($r = -.14$, $p = .042$) was observed in the Spanish sample.

of Norwegian and Spanish undergraduate students, respectively. In addition, our study of dimensionality in topic-specific personal epistemology across cultures was limited to the topic of climate change. It is therefore important that future researchers extend our contribution to encompass other student groups as well as other topics.

It could also be argued that some participants reported epistemic beliefs more in accordance with the prevalent or politically correct view on knowledge and knowing concerning climate change than with their own personal view. This possibility does not make it less reasonable to interpret the similarities and differences that we identified as culturally embedded, however. Because self-reports of epistemic beliefs on a questionnaire may differ from what participants actually do when dealing with a particular topic, that is, from their epistemic beliefs in action, one way to validate such self-reported beliefs is to compare them with ongoing epistemic judgment and monitoring as assessed through think alouds (Hofer 2004c; Mason and Boldrin 2008).

Despite the limitations, we maintain that our study may initiate an important line of cross-cultural research on topic-specific personal epistemology. Indeed, how people in different countries view knowledge and knowing about issues of vital importance, such as climate change, may be crucial for how those problems are understood and, eventually, solved. Questions concerning how knowledge and knowing about important topics are conceptualized in different cultural contexts, as well as the factors that may constrain and enhance the development of more adaptive topic-specific epistemic beliefs, should therefore be more fully addressed in the wake of this preliminary work.

Appendix

Sample items for the topic knowledge measure (* = correct answer)

The Kyoto Protocol deals with

(a) trade agreements between rich and poor countries
(b) reduction in the discharge of climate gases*
(c) the pollution of the Pacific Ocean
(d) protection of the ozone layer
(e) limitations on international whaling

The greenhouse effect is due to

(a) holes in the ozone layer
(b) increased use of nuclear energy
(c) increased occurrence of acidic precipitation
(d) streams of heat that do not get out of the atmosphere*
(e) the pollution of the oceans

Climate gases

(a) do not occur naturally in the atmosphere
(b) are necessary for much of the life on the earth*
(c) did not exist in pre-industrial times
(d) are exclusively synthetic combinations
(e) can cause legionnaires' disease

Acknowledgements This research was supported by a grant from the Research Council of Norway. Thanks are due to Drs. Ramiro Gilabert and Marit Samuelstuen for the collection of data used to compute the test-retest reliabilities of the topic knowledge measure.

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